JACC: CASE REPORTS VOL. 28, 2023

CASE REPORT

CLINICAL CASE

A Case of Aborted Sudden Cardiac Death Due to Coronary Artery Spasm

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ABSTRACT

Coronary artery spasm remains an important yet rarely recognized cause of myocardial ischemia, which may manifest as vasospastic angina, ventricular arrhythmia, or sudden cardiac death. Here we present a case of ST-segment elevation myocardial infarction complicated by cardiac arrest secondary to coronary artery spasm, diagnosed with invasive coronary function testing. (J Am Coll Cardiol Case Rep 2023;28:102127) © 2023 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

HISTORY OF PRESENTATION

A 39-year-old male patient experienced chest pain during an appointment with his family physician. Attending paramedics witnessed the patient develop ventricular fibrillation (VF) (**Figure 1**), which was successfully treated with a 200-J shock. On arrival to the emergency department (ED), the patient was alert, with a blood pressure of 122/80 mm Hg and a heart rate of 85 beats/min.

LEARNING OBJECTIVES

- To recognize that CAS is a frequently underdiagnosed cause of angina and malignant VA.
- To understand the importance of CFT for diagnosing CAS.
- To recognize the importance of a multidisciplinary approach when managing CAS-induced VA and the potential role for primary prevention ICD.

PAST MEDICAL HISTORY

The patient gave a history of chronic back pain for which he was prescribed regular pregabalin and paracetamol. He was a nonsmoker.

DIFFERENTIAL DIAGNOSIS

Differential diagnoses included plaque erosion or rupture, coronary embolism or thrombus, coronary artery spasm (CAS), spontaneous coronary artery dissection, and nonischemic mechanisms such as stress-induced cardiomyopathy or myocarditis.

INVESTIGATIONS

Prehospital electrocardiography (ECG) demonstrated ST-segment elevation in leads V_2 to V_5 (**Figure 2**). Emergency coronary angiography demonstrated patent coronary arteries (Videos 1 and 2). Optical coherence tomography (OCT) findings were suggestive of plaque erosion within the left anterior descending (LAD) coronary artery, but with no evidence of thrombus, dissection, or vasospasm (Video 3). The

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

Manuscript received October 2, 2023; revised manuscript received October 17, 2023, accepted October 25, 2023.

ISSN 2666-0849 https://doi.org/10.1016/j.jaccas.2023.102127

ABBREVIATIONS AND ACRONYMS

ACh = acetylcholine

ANOCA = angina with nonobstructed coronary arteries

CAS = coronary artery spasm

CCB = calcium-channel blocker

CFT = coronary function testing

CMR = cardiac magnetic resonance

ECG = electrocardiography

ED = emergency department

GTN = glyceryl trinitrate

ICD = implantable cardioverter-defibrillator

LAD = left anterior descending

MINOCA = myocardial infarction with nonobstructive coronary arteries

OCT = optical coherence tomography

OOHCA = out-of-hospital cardiac arrest

VA = ventricular arrhythmia

VF = ventricular fibrillation

initial troponin level was normal (<26 ng/L) and peaked at 301 ng/L (12 hours). A transthoracic echocardiogram on day 1 demonstrated good biventricular function with no regional wall abnormalities.

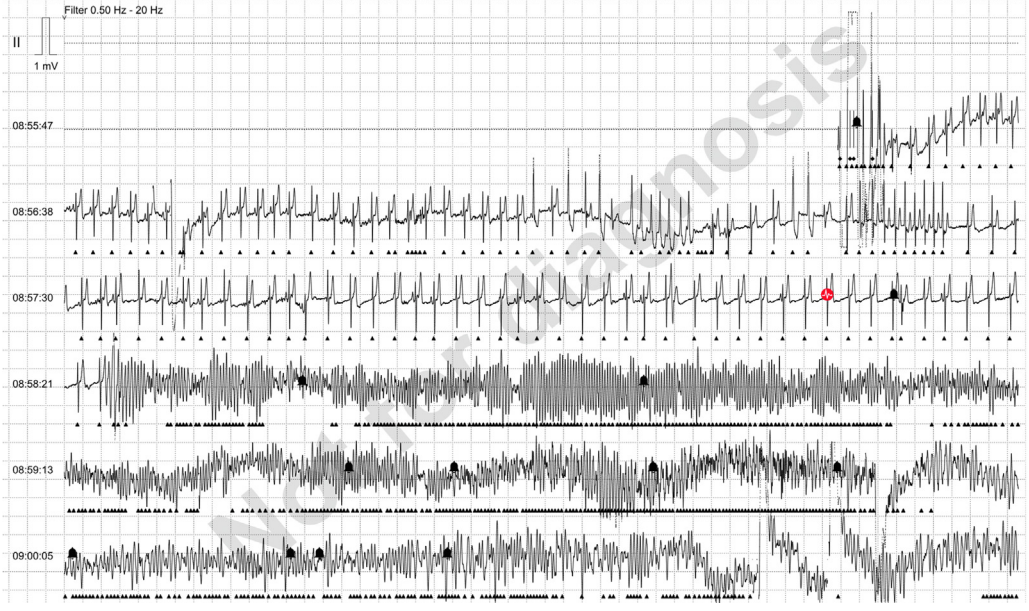
MANAGEMENT

Following admission, the patient remained hemodynamically stable, with no further episodes of chest pain or ventricular arrhythmia (VA) and downward trending troponin. On day 3, the patient was discharged with a diagnosis of VF secondary to myocardial ischemia. For further diagnostic clarification, he underwent outpatient cardiac magnetic resonance (CMR) 1 week following discharge. This scan demonstrated good biventricular function with no evidence of myocardial infarction or fibrosis on contrast imaging (Figure 3).

During the subsequent 36 months, the patient continued to experience troublesome chest tightness. Symptoms came on at rest and during the early hours of the morning, were not associated with clear triggers, and were relieved by glyceryl trinitrate (GTN). Multiple ED presentations revealed negative or mildly elevated troponin levels (peak 27 ng/L), and ECG showed no ischemic changes. Computed tomography coronary angiography at 30 months demonstrated patent coronary arteries and a calcium score of 1. The patient's working diagnosis was changed to vasospastic angina, and treatment was initiated with isosorbide mononitrate and diltiazem. Notably, during a further chest pain admission to another hospital, a secondary prevention implantable cardioverter-defibrillator (ICD) was inserted.

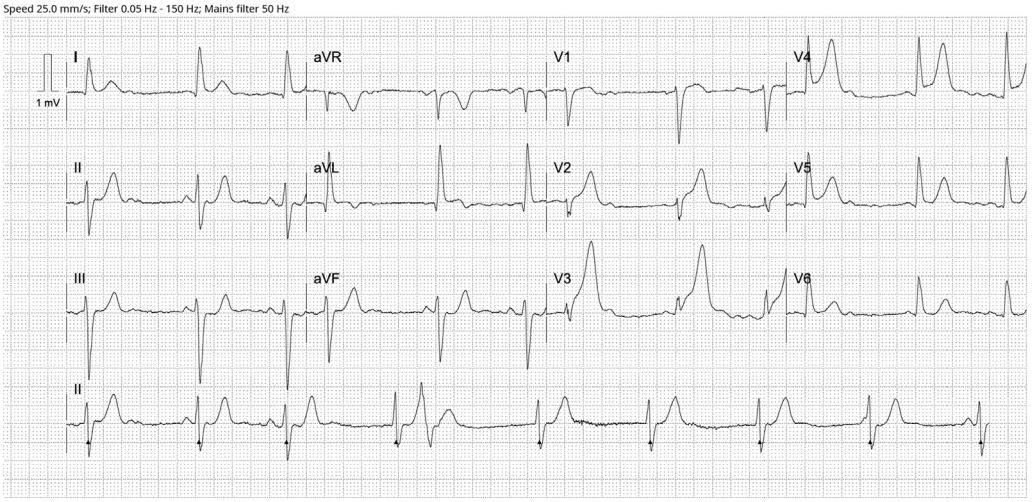
Given the troublesome nature of his symptoms, the patient was referred for invasive coronary function testing (CFT) to identify the disease endotype and for risk stratification. Indices of microcirculatory resistance were assessed (with the Coroventis CoroFlow System and PressureWire X, Abbott), and intracoronary acetylcholine (ACh) was used to detect CAS. Results within the LAD artery demonstrated normal coronary flow reserve (13.5; normal, ≥2.5) and index of microcirculatory resistance (8; normal <25) (Figure 4). However, following intracoronary administration of 20 μg ACh, the left-sided coronary system demonstrated profound or occlusive vasospasm (Video 4) associated with chest pain and ST-segment elevation (Figure 5). Real-time intracoronary pressure measurements from the pressure wire in the LAD artery demonstrated a fall in the ratio of distal coronary pressure to aortic pressure (Pd/Pa) from 0.97 to

FIGURE 1 Presenting Electrocardiographic Tracing



Atrial fibrillation degenerating into ventricular fibrillation.

FIGURE 2 Postshock 12-Lead Electrocardiogram



Sinus rhythm with ST-segment elevation (leads V_2-V_5).

0.17 (normal, ≥0.92), signaling the presence of occlusive vasospasm (**Figure 6**), which was reversed using intracoronary GTN (Video 5). The patient's medical therapy was subsequently stratified toward treating isolated epicardial CAS with up-titration of calcium-channel blockers (CCBs) and nitrates.

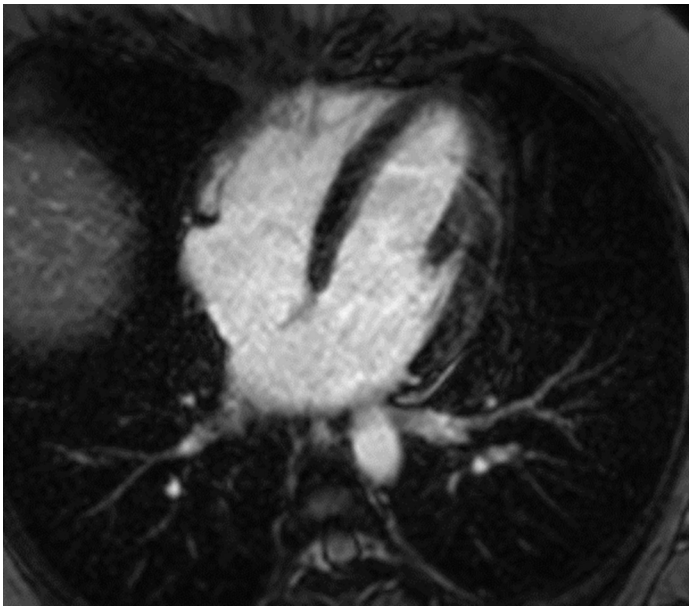
DISCUSSION

CAS remains an important yet underrecognized pathophysiological mechanism for patients with angina and nonobstructive coronary arteries (ANOCA). In a meta-analysis of 6,553 patients with ANOCA, it was estimated that the prevalence of epicardial CAS was 40%.[1] In the CorMicA (CORonary MICrovascular Angina) study, 37% of patients with ANOCA experienced CAS with intracoronary ACh provocation.[2] Despite an increasing awareness of CAS, the prevalence remains unclear because CFT is rarely performed.

CAS is caused by transient smooth muscle hyperreactivity and vascular wall hypertonicity. Pathogenesis of the condition is likely to be multifactorial, including autonomic nervous system dysfunction, oxidative stress, chronic inflammation, endothelial dysfunction, and atherosclerosis.[3] Risk factors for developing CAS include tobacco smoking, increased age, elevated C-reactive protein, hypertension, dyslipidemia, and diabetes mellitus.[3]

Clinical presentation of CAS is variable but generally involves a pattern of chronic recurrent chest pain that is nitrate responsive, occurring typically at rest or between night and early morning. Recognized triggers include emotional and mental stress, prescription medications, recreational drugs, magnesium deficiency, hyperventilation, and allergy

FIGURE 3 Follow-Up Cardiac Magnetic Resonance



No evidence of late gadolinium enhancement, thus suggesting no previous myocardial infarction or myocarditis.

FIGURE 4 **Indices of Microcirculatory Resistance With the Coroventis CoroFlow System (Abbott)**

Normal coronary flow reserve (CFR) and index of microcirculatory resistance (IMR), suggesting normal coronary microvascular function. FFR = fractional flow reserve; Pa = aortic pressure; Pd = distal coronary pressure; RRR = resistance reserve ratio.

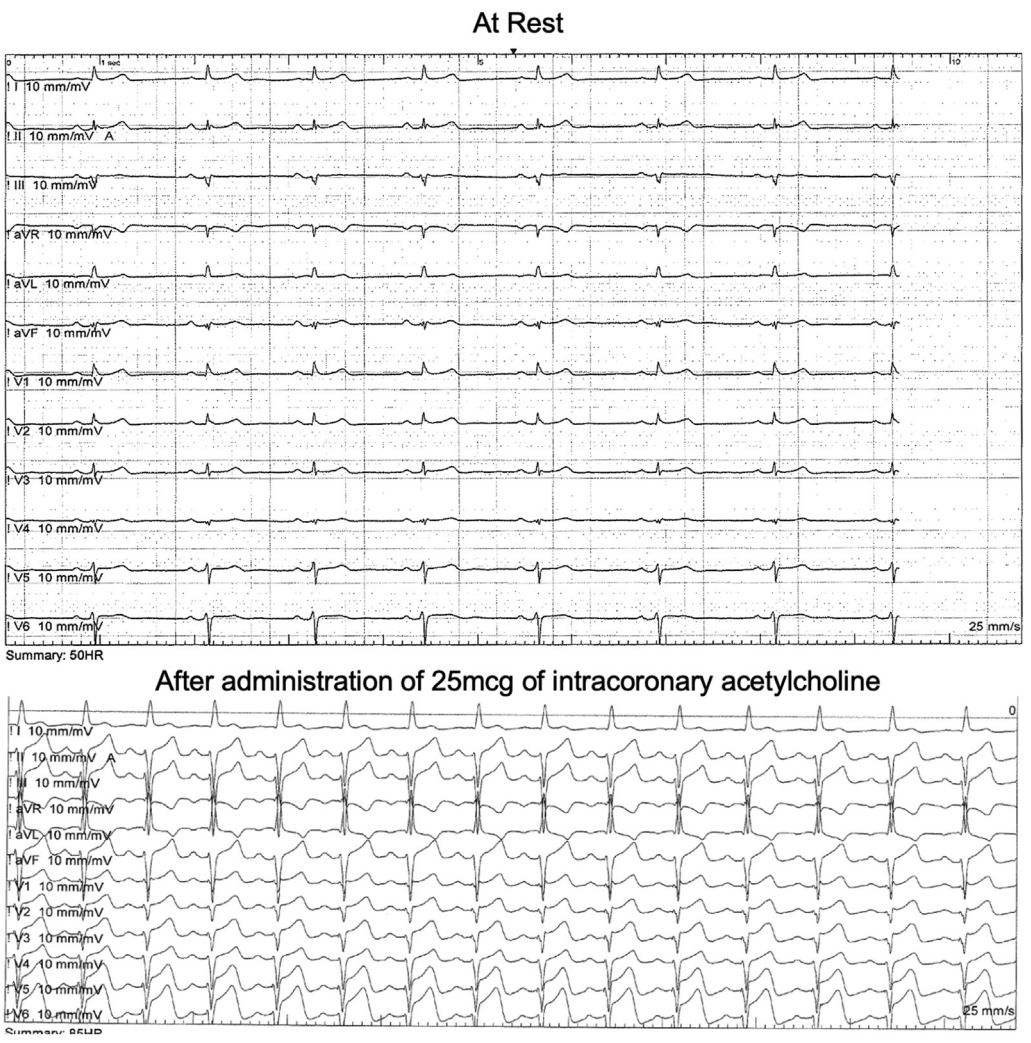
(ie, Kounis syndrome).[4] VAs, including VF, ventricular tachycardia, and sudden cardiac death (SCD), have been reported in 5% to 15% of patients with CAS.[5] Crucially, VA may be the patient's index presentation with CAS. The mechanism for VA in CAS is not well understood, but VA may occur secondary to repolarization abnormalities from CAS-induced ischemia or the formation of malignant re-entry circuits around myocardial scar from a previous CAS-related myocardial infarction.

Diagnosing CAS is challenging because of the heterogenous nature of the condition. Recently, the Coronary Vasomotion Disorders International Study Group (COVADIS) established diagnostic criteria on the basis of 3 elements: 1) angina responsive to nitrates; 2) evidence of CAS on coronary angiography; and 3) transient ischemic changes on ECG during spontaneous episodes.[1] Invasive CFT remains the gold standard for diagnosis, with diagnostic criteria for epicardial CAS satisfied by transient total or subtotal coronary artery occlusion (>90% lumen reduction) in the presence of angina and ischemic ECG changes.[6] Intracoronary ergonovine and ACh are the most commonly used provocative agents, both of which provoke cell-mediated vasoconstriction among patients with endothelial dysfunction. COVADIS recommends CFT in patients with a high pretest probability of CAS, myocardial infarction with nonobstructive coronary arteries (MINOCA). and unexplained resuscitated cardiac arrest.[6] Because diagnostic certainty may influence therapeutic strategies and risk stratification, a multimodality imaging approach should be considered, using coronary angiography, intravascular imaging, CMR, and CFT. Notably, HARP (Heart Attack Research Program-Imaging Study) demonstrated that among patients with MINOCA, CMR with OCT can help identify a diagnostic mechanism in 85% of patients.[7]

Treatment goals in patients with CAS are to prevent serious complications such as myocardial infarction and VA and to improve quality of life by reducing the frequency and severity of symptoms. Lifestyle modification remains essential, including smoking cessation and avoidance of possible triggers. Pharmacologic treatment is the cornerstone for all CAS patients, and it includes nitrates and CCBs. Magnesium supplementation should be considered in patients with hypomagnesemia. Of note, β-blockers should be avoided because they exacerbate CAS by allowing unopposed α-adrenergic activity.

CAS patients with malignant VAs are challenging to manage and should involve a multidisciplinary team. CCBs have been shown to prevent CAS-induced VA. In a retrospective, multicentered study, non-dihydropyridine CCBs were associated with a lower rate of ICD shocks and helped suppress VA recurrence.[8,9] However, the role of ICDs in patients with presumed CAS-induced VA remains controversial. Chevalier et al[9] suggested a favorable prognosis in

FIGURE 5 12-Lead Electrocardiogram During Coronary Function Testing



Normal at rest; ST-segment elevation (leads V_1-V_6) after intracoronary acetylcholine resulting from vasospasm-induced ischemia.

patients who were receiving appropriate medical therapy without ICD insertion; however, Ahn et al[10] demonstrated that patients with CAS complicated by cardiac arrest often received appropriate ICD therapies (32 per 1,000 patient-years).[9,10] Currently, no guidelines exist to help guide decisions regarding primary prevention ICD in patients with CAS. The general consensus states that ICD insertion should be reserved for secondary prevention among patients who survive aborted SCD or VA.

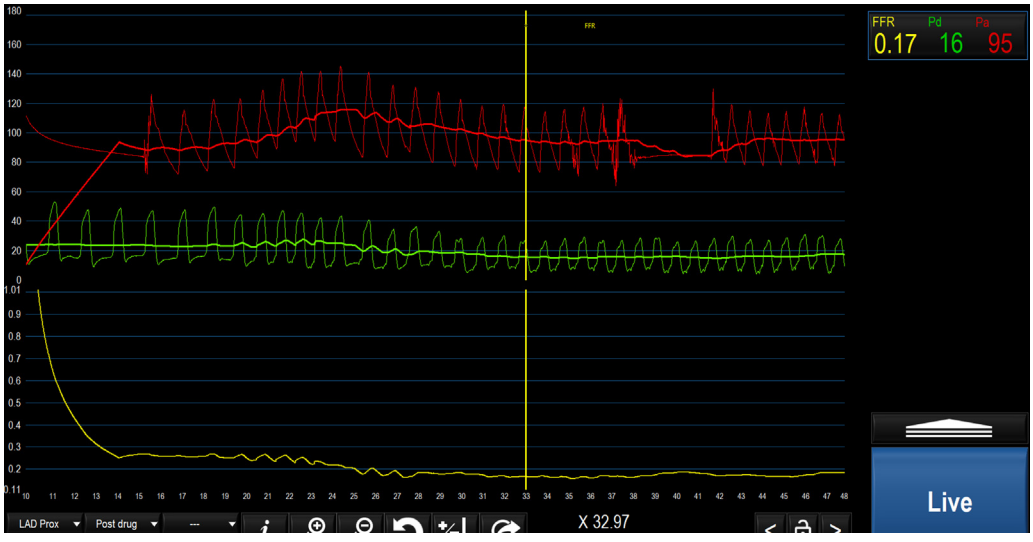
FOLLOW-UP

Following CFT, the patient reported improved quality of life, which he attributed to receiving a definite diagnosis from CFT and up-titration of his pharmacotherapy. An ICD check showed no evidence of recurrent VA.

CONCLUSIONS

CAS remains an underrecognized cause of cardiac chest pain that may not only lead to a significant reduction in quality of life but may also cause SCD. CFT with provocation testing is the gold standard for diagnosis. Although lifestyle modification and pharmacotherapy may be helpful in treating CAS, ICD insertion should be considered among patients with CAS-associated aborted sudden death and VA.

FIGURE 6 Pd/Pa Ratio During Intracoronary Acetylcholine Administration



Progressive decline to 0.17 indicating profound vasospasm and occlusion. LAD = left anterior descending coronary artery; other abbreviations as in Figure 4.

FUNDING SUPPORT AND AUTHOR DISCLOSURES

Dr Spiro has received honoraria from Abbott Vascular. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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KEY WORDS acute coronary syndrome, cardiac arrest, coronary artery spasm, STEMI

APPENDIX For supplemental videos, please see the online version of this paper.